Medical Student Perspectives on the Use of Immersive Virtual Reality for Clinical Assessment Training

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WHAT'S NEW?

Medical students reported an immersive virtual reality (VR) curriculum on respiratory distress as clinically accurate and likely to impact future patient assessment. VR training was rated as equally or more effective than high-fidelity mannequins and standardized patients but less effective than bedside teaching.

BACKGROUND

THE PRACTICE OF medicine has traditionally relied on an apprenticeship model for clinical training – an approach in which bedside teaching was the primary source for knowledge transfer. However, the frequency of bedside teaching is declining due to duty hour restrictions, increased patient turnover, and competing demands for physicians' time.[1–3]

Alternatives to bedside teaching have emerged including simulation-based medical education though current approaches are limited in applicability to and functionality for pediatric training.[4–8] For instance, standardized patients are not available for many pediatric conditions especially for diseases that predominantly affect infants. Moreover, patient simulators often cannot display critical physical exam findings for discriminating between sick and healthy patients (eg mental status, work of breathing, perfusion changes).

An emerging educational modality, immersive virtual reality (VR), could potentially fill this gap. Immersive VR utilizes a three-dimensional, computer generated environment in which users interact with graphical characters (avatars). While screen-based simulation training has been demonstrated to enhance learning outcomes,[9,10] immersive VR has the potential to have a broader impact through increased learner engagement, and improved spatial representation and learning contextualization.[11] To date, this technology has demonstrated effectiveness in communication skills training; however, it has not been investigated for clinical assessment training.[12,13] To evaluate the role of immersive VR in medical student clinical assessment training, we created a VR curriculum focused on respiratory distress in infants. Our pilot study explored medical student attitudes toward VR and perceptions of VR compared to other common medical educational methods.

EDUCATIONAL APPROACH AND INNOVATION

SETTING AND STUDY POPULATION

An IRB approved prospective pilot study was conducted at Cincinnati Children's Hospital Medical Center, a large academic children's hospital, during the 2017 to 2018 academic year. A randomized sample of third-year medical students, based upon predetermined clinical team assignment during their pediatric rotation, was invited to participate in a VR curriculum.

CURRICULUM DESIGN

The curricular goal, to improve third year medical students' ability to appropriately categorize a pediatric

patient's respiratory status, aligns with an Association of American Medical Colleges Core Entrustable Professional Activity for entering residency, the ability to recognize a patient that requires an urgent or emergent escalation of care.[14]

To address this goal, an immersive VR curriculum using the clinical scenario of an admitted infant with bronchiolitis was developed collaboratively between clinicians, educators, and simulation developers. A virtual Cincinnati Children's Hospital Medical Center inpatient hospital room was created using the Unity development platform and was experienced through an Oculus Rift headset. The environment included a vital signs monitor, virtual stethoscope, and avatars for the patient and preceptor (https://drive.google.com/file/d/1m-1j7hbxvIudK1jdgz9MRQYcubS6-IS/view?usp=sharing). The patient avatar could demonstrate key exam findings (ie mental status, work of breathing, and breath sounds) that correlated with three clinical scenarios: 1) no distress, 2) respiratory distress, and 3) impending respiratory failure. The displayed vital signs and auscultatory findings matched the clinical status of the patient. Learners received feedback on their performance immediately following each simulated case. The preceptor avatar, controlled by a physician facilitator (M.Z., F.R.), guided the student through the VR simulation. Learners were expected to recognize and interpret the vital signs, physical exam, and auscultatory findings and come to an overall assessment of the patient's respiratory status. Detailed algorithms correlating learner input to avatar responses allowed for standardization of the avatar preceptor prompts. For example, if a student did not comment on the patient's lung sounds, the facilitator is guided to select the avatar prompt, "What do you think of his lung sounds?" Facilitator-provided feedback for each scenario was standardized to ensure consistent learner experiences.

Scenarios were piloted on four critical care attending physicians, two hospitalists, two general pediatricians, four critical care fellows, four senior pediatric residents, and four medical students to assess the accuracy of the findings portrayed in the clinical scenarios as well as the feasibility of the planned facilitation. Iterative changes were made to the VR simulation based upon feedback.

Survey Design and Implementation

Immediately following the VR curriculum, students completed a survey to assess immersion within the VR environment using questions derived from a validated instrument.[15] Demographic data and attitudes toward the VR curriculum including its perceived effectiveness compared to other education methods were assessed on a 5-point Likert scale via a survey created de novo with piloting prior to use. Survey results were analyzed with binomial testing.

Results

All eligible students consented to participate in the research study (n = 78). Ages ranged from 20 to 39 with an equal distribution between male and female. Students self-identified as White (51.3%), Asian (28.2%), Black (7.7%), Hispanic/Latino (3.9%), or other (9.0%). Most students reported a strong sense of presence in the VR environment (85%) and the vast majority noted that the scenarios captured their attention and senses (96% and 91%, respectively).

A majority of students agreed or strongly agreed that that the simulations were clinically accurate (97.4%), reinforced key learning objectives (100%), and would impact future care provision (98.7%). In addition, students reported VR training as more effective ($P < .001$) than reading, didactic teaching, online learning, and low fidelity mannequins. VR training was rated as equally or more effective ($P < .001$) than high fidelity mannequins and standardized patients. The only modality that VR was rated less effective than was bedside teaching (Figure).

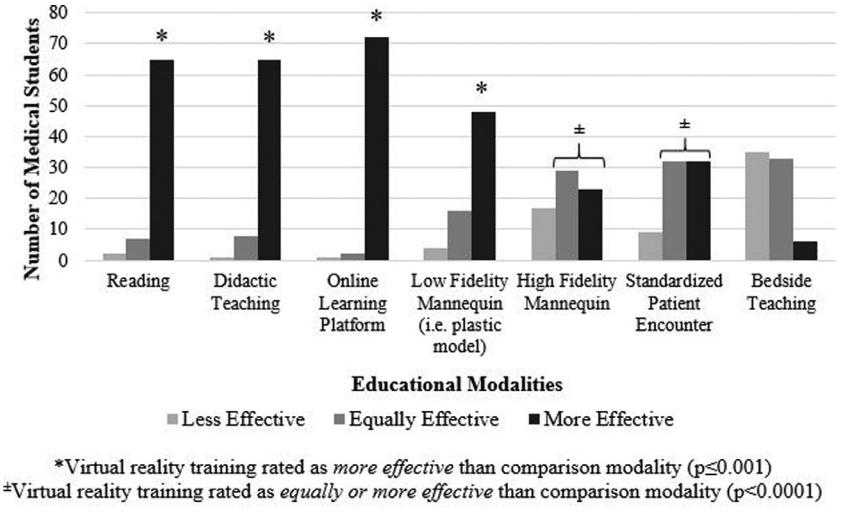

Figure. *Binomial testing demonstrates that a statistical majority of students found virtual reality training more effective than reading, didactic teaching, online learning, and low fidelity mannequins, and equally or more effective than high fidelity mannequins and standardized patients.*

DISCUSSION AND NEXT STEPS

This study represents a novel application of immersive VR for medical student training. The majority of student participants reported a sense of presence within the VR environment and identified the modality as equal or superior in perceived effectiveness to other training options such as standardized patients and high-fidelity mannequin simulations while rated less effective than bedside teaching. These findings are consistent with the findings of Real et al[13] that learners perceived VR as equally effective to standardized patients for communication training. Our learners expressed similar perceptions regarding the use of VR for clinical assessment training – expanding the potential applications for VR-based education.

The assessment of a patient's respiratory status, and importantly the recognition of need for emergent escalation of care is a core clinical competency that directly relates to patient safety.[14] The ability of immersive VR to convey specific critical exam findings could aid in accelerating junior learners' competence related to identification of impending respiratory failure and potentially impact future care provision. The learnings from this pilot could be applied to other clinical scenarios (eg sepsis) given immersive VR's ability to accurately simulate key exam findings.

This study has several limitations. First, it was conducted at a single site with only third year medical students. Second, the evaluation focused on students' perceptions toward the effectiveness of VR-based education in general rather than specifically focusing on VR-based education on pediatric respiratory distress. Though we could not standardize students' exposure to the comparison education modalities, all students underwent a high-fidelity simulation focused on respiratory distress as part of their pediatric rotation. This high fidelity simulation occurred prior to the VR curriculum, and thus represented a consistent reference for all of the students who completed the study survey.

A final significant consideration for this study is the generalizability of the approach. With each passing year and iteration of available equipment, the cost of VR compatible headsets and computers continue to fall. We utilized the Oculus Rift headset and a VR capable computer, which together cost on the order of $2000. The development platform, Unity, is an open source platform available at no cost. We are fortunate to have VR developers as employees of our simulation center, facilitating the development of new scenarios, and represent a resource that may currently be unavailable at many other institutions.

Next steps include establishing response process validity through assessment of learner application of knowledge gained during the VR curriculum. Additional research goals include exploring the effectiveness of immersive VR at additional sites to assess generalizability, directly comparing VR head-to-head with other educational modalities (eg standardized patients, high-fidelity simulations), and evaluating change in actual clinical practice as well as the costs associated with these modalities to explore the feasibility of broader implementation of VR training. The findings from this pilot study suggest that immersive VR may be an effective supplement to bedside teaching due to its ability to accurately represent real-life environments and clinical scenarios in a standardized format that is safe for learners and patients.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.acap.2019.06.008.

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